RHIC RUN 2000 PLANS*

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Abstract

After the 1999 test run, the year 2000 run will complete the RHIC commissioning and will also be the first run for physics. The main goal is to achieve 10% of the design luminosity at 70% of the design energy in gold operation. In addition, polarized protons will be stored and accelerated in one of the two rings.

1 INTRODUCTION

In 1999 the two RHIC rings were tested in a two months long run. Gold beam was stored at injection energy in both rings and accelerated by a small amount in one of the rings. Most of the systems and instrumentation were commissioned.

For the 2000 run the plan is to accelerate gold beams to 70% of the design energy and collide the beams, producing up to 10% of the design luminosity. More instrumentation systems, notably tune measurement systems, are to be commissioned. For the first time polarized beam will be transferred into one of the rings and accelerated.

2 RHIC STATUS AFTER TEST RUN AND MAINTENANCE PERIOD

During the 1999 test run the injector chain, consisting of the source, Tandem, Booster and the AGS, worked well and reliably. The intensity per bunch of the gold beam reached 50% of the design value. Transverse and longitudinal emittances, as measured in the AGS, were within the design specifications.

Fig. 1 shows the preparation of bunches in the AGS. 20 bunches are injected from the Booster. One out of 6 bunches is lost in the transfer due to insufficient kicker pulse length. At injection energy the beam is then debunched and rebunched into 4 bunches. The debunch-rebunch process takes 100ms and results in bunches with an area of 0.3eV$\cdot$s/u.

During the test run the refrigerator worked well and all RHIC magnets were tested up to 40% of the maximum operating field. Beam was circulated and captured by the rf in both rings despite a severely restricted physical aperture (see below). Fig. 2 shows the beam current at injection in the Blue ring with a lifetime of 19 minutes. Beam could be stored for up to 45 minutes in the Blue ring and for a few thousand turns in the Yellow ring. Beam in the Blue ring was accelerated by a modest amount, about 1GeV/u.

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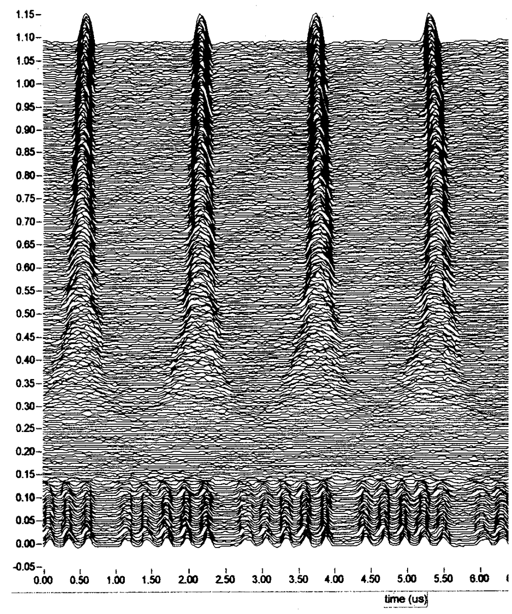

Figure 1: RHIC bunch preparation in the AGS. 24 bunches are injected, debunched and rebunched into 4 bunches with an longitudinal area of 0.3eV$\cdot$s/u. The time from debunching to rebunching is 100ms.

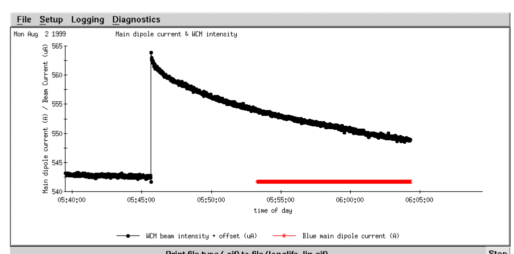

Figure 2: Beam current in the Blue ring showing a lifetime of 19 minutes.

Beam instrumentation systems were commissioned. The beam loss monitors and beam position monitors reached operational performance. It was demonstrated that a novel Ionization Profile Monitor (IPM) can record transverse profiles turn-by-turn.

Measurements of the RHIC lattice properties were performed. In Fig. 3 such a measurement is shown where a predicted difference orbit is compared with a measured one. The difference orbit is taken from closed orbits with and without a vertical orbit corrector. Measured and predicted difference orbits agree very well except for a few BPMs, which are reversed. For these, agreement is also good after sign reversal. Difference orbits were used to identify reversed BPMs. Fig. 4 shows a measurement of multi-turn orbit rms from which the β-functions can be deduced.

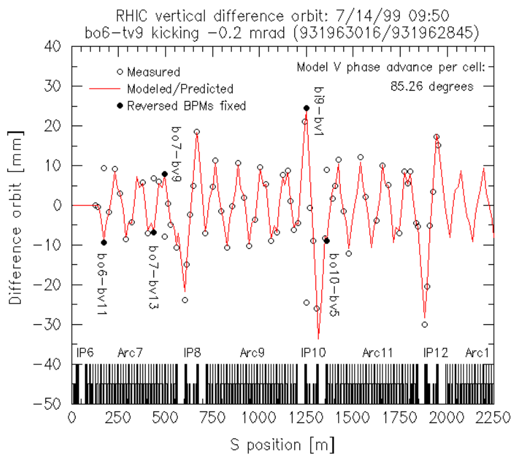

Figure 3: Measured and predicted difference orbits in one half of the ring. The difference orbit is taken from orbits with and without a vertical orbit corrector. The difference orbit was used to identify four reversed BPMs. Except for these predicted and measured difference orbits agree very well.

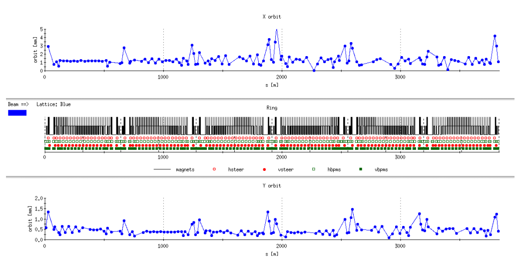

Figure 4: Multi-turn orbit rms in the Blue ring for a β-function measurement.

In 1999, the physical aperture in both rings was severely limited by distorted beam tube bellows (see Fig. 5). During high pressure tests of the Helium process lines, the dummy sections (drift lines without magnets) moved sideways. All 192 dummy inter-connects had to be opened and the bellows repaired.

The power supply systems was not fully completed in 1999. Not all of the interaction region shunt power supplies were delivered in time. This made it necessary to run with a small β^* of 3m in all interaction regions instead of the nominal injection optics that has a β^* of 10m. In addition, the power supply system did not yet provide the nominal ramp rates for acceleration. Measurements of transfer functions and field errors were performed for different ramp rates (see Fig. 6 for a quadrupole measurement). Neither the transfer functions nor the field errors depend on the ramp rate which will make it easier to slowly increase the ramp rate to the nominal value in the next run.

Figure 5: Distorted bellows of Helium process lines in a dummy section.

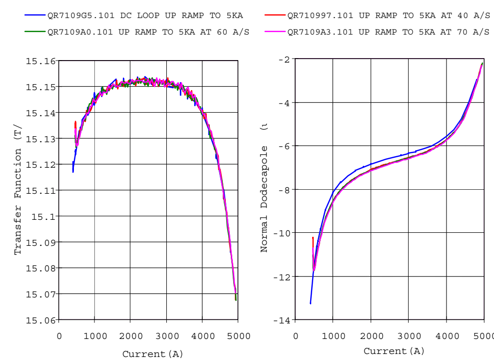

Figure 6: Transfer function and dodecapole measurement of and arc quadrupole at different current ramp rates. There is practically no difference between ramp rates.

3 GOALS FOR RUN 2000

There are two main goals for the RHIC Run 2000. First, gold beams are to be accelerated in both rings to 65 GeV/u and brought into collision. The target luminosity is 10% of the design value of $2 \cdot 10^{26}\mathrm{cm}^{-2}\mathrm{s}^{-1}$. For this, close to 60 bunches have to be accelerated and stored in each ring. With established collisions, the RHIC physics program will begin. The second goal is to inject polarized protons in one ring, measure the polarization and accelerate the polarized proton beam.

To achieve gold acceleration to the target energy, the transition energy has to be crossed in a superconducting machine for the first time. The RHIC design included a γ_t-jump in order to minimize the beam time close to the transition energy. Nominally, 48 quadrupoles in each ring would be turned off within 60ms to change the γ_t fast with a steadily accelerating beam (see Fig. 7). However, the pulsed power supplies for this scheme are not yet available.

Instead, before reaching transition, the orbit radius will be first reduced. This results in a beam energy that is lower

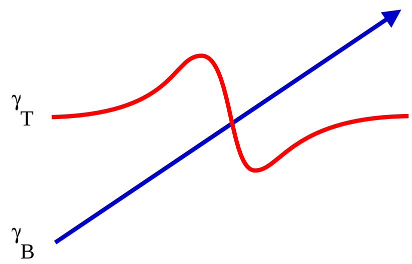

Figure 7: Schematic of a transition crossing with a γ_t-jump. Pulsed quadrupoles are needed for this scheme.

than with a constant radius. To cross transition, the beam will then be accelerated as fast as possible. This will result in an increased orbit radius. The radius can then be lowered slowly to bring the beam again in the middle of the beam pipe. This scheme is shown in Fig. 8.

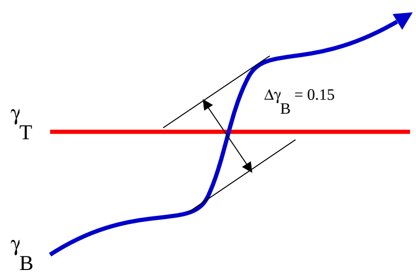

Figure 8: Schematic of a transition crossing with a radius and thereby energy jump. Sufficient radial aperture is needed for this scheme.

In gold operation, intra-beam scattering will be an important effect at injection and storage. Intra-beam scattering will grow all three beam dimensions during stores, and computations predict a significant drop in the instantaneous luminosity due to this effect. Fig. 9 shows the result of such a computation for a storage time of 10 hours.

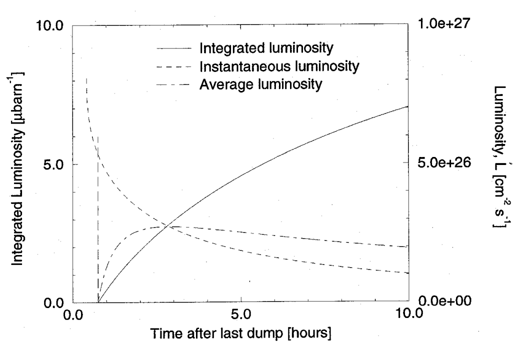

Figure 9: Computed instantaneous, integrated and average luminosity as a function of time. The instantaneous luminosity drops with time since the beams grows in all three dimensions primarily due to intra-beam scattering.

After the end of the gold run, it is planned to operate RHIC with polarized protons. Ultimately, each RHIC ring will have two Siberian snakes (each consisting of four helical magnets) to overcome depolarizing resonances, and four spin rotators (also consisting of four helical magnets) that allow to collide longitudinally polarized protons at two of the RHIC experiments, STAR and PHENIX. Each ring will also be equipped with a polarimeter.

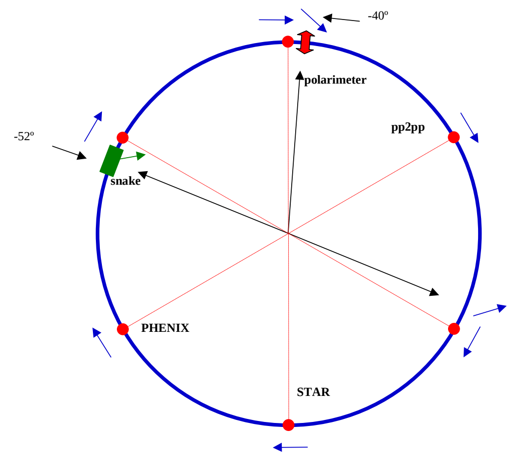

Figure 10: Location of the snake and the polarimeter in the Blue ring that are available for the Run 2000.

For the Run 2000, a new source for polarized protons will be available, one Siberian snake and a polarimeter in the Blue ring (see Fig. 10). Polarized proton operation will therefore be restricted to one ring. The goal for the test run with polarized protons is to inject polarized protons into the RHIC Blue ring, measure polarization with the polarimeter, operate the Siberian snake and finally accelerate beam while preserving polarization.

After the operating period with beam, the quench protection system for the DX magnets will be fully commissioned. This will allow to ramp the rings up to the full design energy in the next run.

Fig. 11 depicts the schedule for the year 2000. Operation with beam will start in March. It is planned to inject and store beams at injection in both rings, accelerate them and establish collisions. Polarized proton operation is at the end of the run.

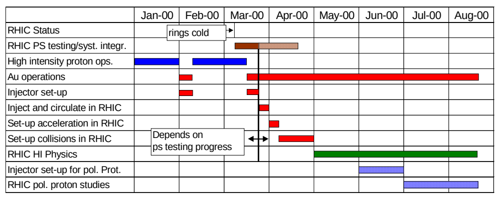

Figure 11: Schedule for the RHIC 2000 run.

4 ACKNOWLEDGMENTS

This review of the 1999 RHIC performance and the plans for the RHIC Run 2000 reflects the work of the whole Collider-Accelerator Department at BNL.